Simulation of Nitrogen Dynamics in Potato Systems in the Pacific Northwest

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Introduction

In the irrigated agricultural production region of the Pacific Northwest (PNW), potato is grown predominantly with center pivot irrigation system. Soil used for potato production is generally coarse textured sandy, with low organic matter content. These soils are to vulnerable to nitrogen (N) leaching if water and N are applied in excess. Crop simulation models, coupled with field data, can predict the fate and transport of N while providing basis for improved crop management practices. The potato crop simulation model SIMPOTATO (Hodges et al., 1992), was integrated into the multi-year, multi-crop simulation model CROPSYSTVB (Stockle et al., 1994) to improve model capabilities for the simulation of potato growth and for the assessment of N dynamics. The overall objective of this study was to develop computer based tools that can be incorporated in a decision support system to optimize productivity of the potato-based agricultural systems in the PNW, while minimizing negative effects on the environment.

Objectives

•To compare CROPSYSTVB-SIMPOTATO predictions to field measured data of potato growth and N uptake.

•To use the model to predict the fate and transport of N below the root zone of potato under different N management practices.

Methods and materials

The model

The model used in this study was the CROPSYSTVB-SIMPOTATO, an integration of the multi-year, multi-crop simulation model CROPSYSTVB with the potato crop simulation model SIMPOTATO (Hodges et al, 1992). CROPSYSTVB is a Visual Basic new version of the CropSyst model (Stockle et al, 1994, Stockle et al., 2003) that is currently under development. In the integrated model, CROPSYSTVB provides the framework for weather, location, soil and crop inputs and for daily and annual soil and crop outputs. In CROPSYSTVB-SIMPOTATO, when the crop in the rotation is potato, the phenology and growth of potato, as well as the plant N and carbon balances, are simulated by SIMPOTATO.

The CROPSYSTVB-SIMPOTATO was used to simulate the growth, yield and plant and soil N balances of potatoes using data of three years of a field study as described below.

Field experiment

Ranger Russet cultivar was grown for three years (2001 to 2003) in a sandy soil in the Columbia basin region with different rates of pre plant N. Pre-plant N application rates were: 0, 56, and 112 kg ha^{-1} in 2001 (soil residual N was 56 kg ha^{-1}) and 56, 112, and 168 kg ha^{-1} in 2002 (soil residual N was below detection). Total applied N for the entire growing period across all treatments was 280 kg ha^{-1} in the year 2001 and 336 kg ha^{-1} in the year 2002. Total N including soil residual N was 336 kg ha^{-1} both years. Additional treatments of total applied N of 392 and 448 kg ha^{-1} for the years 2001 and 2002 were also evaluated.

In the year 2003, treatments of pre plant N of 112 and 168 kg ha^{-1} were evaluated. Total applied N for both treatments was 336 kg ha^{-1}.

Tuber yields and soil N levels were measured for all treatments and years. In 2003, leaf area index, leaf, stem and tuber dry matter, tuber fresh matter, leaf, stem and tuber N and leaf and tuber N content were sampled during the growing season. These data were used for more detailed analysis of plant growth and N uptake.

Results

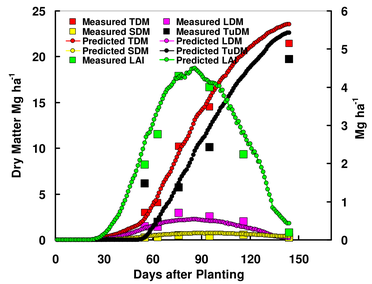

Fig 1. Measured and predicted leaf area index (LAI), total (TDM), leaf (LDM), stem (SDM) and tuber (TuDM) dry matter during 2003.

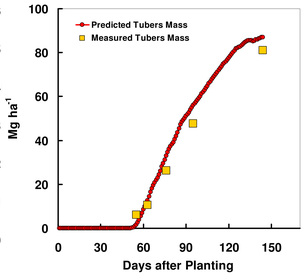

Fig 2. Measured and predicted tuber fresh matter during 2003.

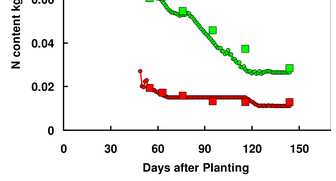

Fig 3. Measured and predicted leaf and tuber N content.

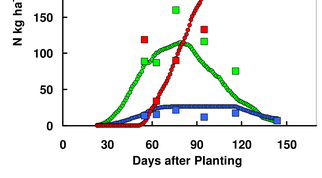

Fig 4. Measured and predicted leaf, stem and tuber N.

Table 1. Applied and measured soil N (kg ha^{-1}), measured yield of tubers (Mg ha^{-1}), and predicted N uptake and leaching (kg ha^{-1}) for different N management in 2001 and 2002.

Year 2001				
Applied Pre Plant N	0	112	56	56
Soil N 0-0.6 m May 2001	84	196	140	140
Soil N 0-0.6 m Sep 2001	49	51	59	43
In season N Fertilization	280	168	224	336
Unaccounted N*	16	14	6	134
Measured Yield (Mg/ha)	65	64	79	79
Predicted N uptake	299	298	298	298
Predicted N leaching	0	0	0	0
Year 2002				
Applied Pre Plant N	56	168	112	112
Soil N 0-0.6 m May 2002	196	308	252	252
Soil N 0-0.6 m Sep 2002	74	98	97	81
In season N Fertilization	280	168	224	336
Unaccounted N*	115	91	91	219
Measured Yield (Mg/ha)	66	68	67	62
Predicted N uptake	288	288	288	288
Predicted N leaching	42	43	43	57

Unaccounted N includes plant N uptake and N losses, and was calculated as:

Unaccounted N=[(Soil N in May) + (In season N)] – [(Soil N in Sept.) + (Crop N uptake#)]

Crop uptake was predicted by the model, since no measured data was available.

The CROPSYSTVB-SIMPOTATO model predicted plant growth and plant N uptake reasonably well for the year 2003 for both the 112 and 168 kg ha^{-1} of pre-plant N experiments. Figures 1 through 4 show predicted and measured results only for the 168 kg ha^{-1} pre-plant N treatment. Predicted values for this experiment of tuber fresh matter and total dry matter at the end of the growing season were 87 Mg ha^{-1} and 23.5 Mg ha^{-1} respectively. Measured values for this experiment were 81 and 21.4 Mg ha^{-1} respectively. During the growing season, predicted leaf area index, leaf, stem and tuber dry matter, tuber fresh matter, leaf, stem and tuber N and leaf and tuber N content compare well with measured values. These results indicate that the model simulated plant growth and N requirement and uptake adequately.

Model predictions for the years 2001 and 2002 show no yield differences across N treatments. Simulated yields for the years 2001 and 2002 were about 72 and 70 Mg ha^{-1} respectively. These predicted yields are in the range of the measured yields for both years.

The model predicted negligible N leaching below the 0.6 m depth for all N treatments in the year 2001. Estimated unaccounted N for the treatment with the highest total applied N (448 kg ha^{-1}) was higher than the unaccounted N estimated for all other treatments of the same year (2001). The later suggests that certain N leaching may have actually occurred in this treatment. This trend was also observed in the year 2002 experiments. For the year 2002, both predictions of N leaching and estimates of unaccounted N, indicate that N leaching increased with the highest rate of N. Irrigation applied in 2002 was about 150 mm greater than that in 2001. This excess of water increased drainage and, therefore, the leaching of N.

Conclusions

Comparison of predicted and measured data showed that the integrated CROPSYSTVB-SIMPOTATO model predicted potato growth and N uptake reasonably well. The inclusion of SIMPOTATO into CROPSYSTVB gave the integrated model improved capabilities to estimate soil and plant N dynamics and production of potato-based cropping systems.

References

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